4. DETAILED ANALYSIS OF ALTERNATIVES

This section presents the detailed analysis of assembled remedial alternatives required by the NCP in 40 CFR 300.430(e)(9). Five alternatives, listed in Table 4-1, were retained for detailed analysis. Each alternative, except No Action, focuses a primary technology (i.e., containment, ISG, ISV, and RTD) on mitigating COCs within the RFP TRU waste contained in Pits 1 through 6 and 9 through 12, Trenches 1 through 10, and Pad A. Assembled alternatives also include supplemental technologies, discussed in Section 3.2 to address other COC-bearing waste streams in the SDA.

Table 4-1. Retained alternatives for Waste Area Group 7.

No.	Alternative Title
1	No action
2	Surface barrier
3	In situ grouting
4	In situ vitrification
5	Retrieval, treatment, and disposal

Alternatives are evaluated in terms of seven of the nine CERCLA (42 USC § 9601 et seq.) criteria defined in EPA guidance (EPA 1988) and presented in Section 4.1. Sections 4.2 through 4.6 provide detailed descriptions and individual analyses of five alternatives. Throughout the analyses, the level of detail provided is conceptual and is offered to facilitate a comparative assessment of the alternatives provided in Section 5.

4.1 Evaluation Criteria

The nine CERCLA criteria for evaluating remedial alternatives listed in Table 4-2 are promulgated under 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan." These criteria address statutory requirements and technical and policy considerations necessary for assessing and selecting remedial alternatives.

The CERCLA criteria fall into three groups: (1) threshold, (2) balancing, and (3) modifying. The first two criteria (i.e., overall protection of human health and the environment, and compliance with ARARs) are threshold criteria that a remedial alternative must meet to be eligible for selection. Alternatives that fail to protect human health and the environment or fail to comply with ARARs (or do not justify a waiver) do not meet statutory requirements for selecting a remedy and are eliminated from further consideration.

The next five criteria are (1) long-term effectiveness and permanence, (2) reduction of toxicity, mobility, or volume through treatment, (3) short-term effectiveness (4) implementability, and (5) cost. These are balancing criteria used to consider significant trade-offs among alternatives. The CERCLA guidance for conducting feasibility studies lists appropriate questions to be answered when evaluating an alternative against the balancing criteria (EPA 1988). These questions are addressed in the detailed analysis presented in this section to provide a consistent basis for evaluating each alternative.

Table 4-2. Comprehensive Environmental Response, Compensation and Liability Act evaluation criteria.

Category	Criteria
Evaluated in this feasibility study	
Threshold	Overall protection of human health and the environment
	Compliance with applicable or relevant and appropriate requirements
Balancing	Long-term effectiveness and permanence
	Reduction of toxicity, mobility, or volume through treatment
	Short-term effectiveness
	Implementability
	Cost
Evaluated in the future record of decision following stakeholder comment on the proposed plan	
Modifying	State acceptance
	Community acceptance

The final two modifying criteria (state and community acceptance) are used in assessing benefits and costs among alternatives that may form the basis of the final selection.

Brief descriptions of the nine criteria are provided in the following subsections. The alternative analysis provided in Sections 4.2 through 4.6 includes assessing the ability of each alternative to satisfy the two threshold and five balancing criteria. The modifying criteria will be evaluated following receipt of stakeholder comments. Analysis of each alternative begins with a description followed by a criterion-by-criterion evaluation. A summary of the screening analysis for each alternative is provided in Appendix C. A detailed presentation of costs is provided in Appendix D.

4.1.1 Threshold Criteria

4.1.1.1 Overall Protection of Human Health and the Environment. The protection evaluation criterion addresses whether an alternative can provide adequate protection of human health and the environment. Protection includes lowering risk to acceptable levels by reducing concentrations or eliminating potential routes for exposure and minimizing exposure threats introduced by actions during remediation. As indicated in EPA guidance (EPA 1988), the protection evaluation criterion overlaps with the criteria for compliance with ARARs, long-term effectiveness and permanence, and short-term effectiveness (EPA 1988).

4.1.1.2 Compliance with Applicable or Relevant and Appropriate Requirements. The NCP (40 CFR 300.430[e][9][B]) requires that alternatives ". . .be assessed to determine whether they need to attain applicable or relevant and appropriate requirements under federal environmental laws and state environmental or facility siting laws or provide grounds for invoking one of the waivers under paragraph (f)(1)(ii)(c) of this section." Cleanup of a CERCLA site must meet requirements or standards promulgated by federal laws and more stringent state laws that relate as ARARs (42 USC § 9621[d][2]).

The ARARs apply to both environmental regulations that direct site cleanup and environmental media criteria that protect human health and the environment. These regulations also promulgate protective requirements for natural, historic, and archaeological resources. However, ARARs do not encompass worker protection requirements addressed under the "Occupational Safety and Health

Administration Act" (OSHA) (20 CFR 1910). While Section 300.150, "Worker Health and Safety," of the NCP does require compliance with general OSHA workplace standards, such standards do not fall within the scope of ARARs under CERCLA (42 USC § 9621[d][2]).

Requirements other than CERCLA-driven ARARs also apply to WAG 7. The TSA within WAG 7 is currently subject to the conditions of a RCRA (42 USC § 6901 et seq.) permit and will be operated and closed in accordance with RCRA permit conditions. It is assumed that the TSA will be closed under RCRA clean-closure requirements.

Preliminary ARARs are identified in the discussions for each alternative. Final determination of ARARs will be completed as part of remedy selection and documented in the ROD.

4.1.2 Balancing Criteria

4.1.2.1 Long-Term Effectiveness and Permanence. The NCP (40 CFR 300.430[e][9][C]) requires that alternatives be ". . .assessed for the long-term effectiveness and permanence they afford, along with the degree of certainty that the alternatives will prove successful." Following are factors considered in the assessment:

- Magnitude of residual risk—Risk remaining from untreated waste or treatment residuals remaining in the SDA source term after remedial activities are completed. Characteristics of the residual waste are considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate.

- Adequacy and reliability of controls—These involve controls (e.g., containment systems and institutional controls) used to manage residual risks associated with treatment residuals or untreated waste that remain at the project site, long-term reliability of management controls necessary for continued protection from residuals, and assessment of potential needs for maintaining and replacing technical components of the alternative.

Residual risk estimates were developed for each remedial action to assess the reduction in human health risks. The evaluations consist of source-release and fate and transport simulations to estimate risk from ingesting groundwater only. Models used to develop risk estimates for the ABRA (Holdren et al. 2002) (e.g., DUST-MS, and TETRAD) also were employed to simulate release and subsurface transport of contaminants to the aquifer beneath the SDA subsequent to hypothetical remediation in 2010.

Infiltration rates and amounts of contamination in the SDA after remediation are principal factors affecting risk estimates. Site-specific technology performance data are unavailable to describe release rates from treated and contained SDA waste. Conservative estimates of release rates for the alternatives were developed based on information in scientific literature. Therefore, risk estimates for each alternative may be higher than the actual residual risk from implementing any alternative. The simplifying assumption that remediation will be instantaneous and complete in 2010 also affects results. In addition, simulated migration of postulated contamination in the vadose zone at the time of remediation is affected only by the change in water movement caused by the remedy. Otherwise, no change in mobility is simulated and the same partition coefficient values are applied. Note also that the influence of the OCVZ system was not included in the modeling. Continuing to operate this system could have a significant effect in reducing groundwater risks associated with VOCs as currently presented in the ABRA.

Beginning in 1952, with the start of SDA operations, groundwater risks are estimated for 10,000 years. Analysis of long-term effectiveness presents the highest estimated risks from ingesting groundwater at the point of maximum cumulative risk. Two scenarios were simulated: (1) one that includes contributions from postulated contamination in vadose zone at the time of remediation and (2) one that ignores postulated contamination in the vadose zone at the time of remediation. Simulations without postulated contamination in the vadose zone provide a basis for evaluating and comparing effectiveness of alternatives in controlling the release of contaminants from the source zone after remediation.

Confidence in the groundwater modeling depends on the representativeness of the geochemical, geophysical, surface water, source release, vadose zone transport modeling, and model calibration. These processes are affected by many parameters, some of which can vary by orders of magnitude and may not be accurately represented in the simulations. Because of the many uncertainties and simplifying assumptions for the fate and transport simulations and risk estimates (see Sections 5 and 6 of the ABRA, Holdren et al. 2002), risk results should not be viewed as accurately predicting future groundwater contamination. Rather, results are used to compare relative long-term effectiveness of the alternatives in preventing future groundwater contamination.

4.1.2.2 Reduction in Toxicity, Mobility, and Volume Through Treatment. The NCP (40 CFR 300.430[e][9][D]) addresses the statutory preference for selecting remedial actions that employ treatment technologies that, as their principal element, permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances. Permanent and significant reduction can be achieved through destroying toxic contaminants, reducing total mass, irreversibly reducing contaminant mobility, or reducing total volume of contaminated media. This criterion focuses the evaluation of an alternative on a variety of specific factors:

- Treatment processes used and materials they treat
- Amount of hazardous materials destroyed or treated
- Degree of expected reduction in toxicity, mobility, or volume described as a percentage of reduction
- Degree to which the treatment is irreversible
- Type and quantity of treatment residuals that remain following treatment
- Ability of the alternative to satisfy the statutory preference for treatment as a principal element.

4.1.2.3 Short-Term Effectiveness. The NCP (40 CFR 300.430[e][9][E]) requires evaluations of an alternative's potential effects on human health and the environment during construction and remediation. The feasibility study evaluations address the following factors for each alternative:

- Protecting the community during remedial actions (specifically, addressing any risk that may result from implementing a remedy [e.g., fugitive dust or transportation of hazardous materials])
- Ensuring the health and safety of remediation workers
- Ensuring the reliability of protective measures
- Mitigating environmental impacts that may result from constructing and implementing remedial actions

- Determining amount of time until the RAOs are met.

Short-term environmental impacts are related primarily to the extent of physical disturbance of habitat. In addition, risk may be associated with the potential disturbance of sensitive species resulting from human activity in the area.

Short-term human health impacts are closely related to exposure duration; specifically, the amount of time a person may be exposed to hazards associated with the waste, its treatment, or its removal. The longer the exposure time, the greater the potential risk. This correlation between exposure duration and risk is a factor in categorizing short-term human health impacts posed by an alternative. One category of potential impacts is the risk to remediation and nonremediation workers from mechanical hazards associated with implementing the alternative and from exposure to hazardous substances, including radioactive materials and radiation fields. Also included, but considered separately, are impacts to workers who support remedial activities but are not part of the remediation staff. Such workers may be exposed to materials released during remedial activities (including excavation, waste packaging, and waste processing) or to radiation fields attributed to waste staging. Potential impacts include radiological risks (collective dose equivalent and excess cancer risk) and OSHA-type accident rates.

Another category of impacts is risks to the public. The public could be impacted through releases of hazardous substances from waste handling and processing activities or from off-INEEL waste transportation exposures to radioactive materials. The public also could be impacted by transportation accidents associated with off-INEEL waste disposal.

The short-term human health impacts associated with each alternative have been quantitatively evaluated and are discussed in detail in a technical report (Schofield 2002) prepared to support development of this PERA.

4.1.2.4 Implementability. The NCP (40 CFR 300.430[e][9][F]) requires that assessment of the ease or difficulty of implementing the alternatives consider the following factors:

- Technical feasibility—Technical difficulties in constructing and operating the alternative, the likelihood of technical problems when implementing the technology that might lead to schedule delays, ease of implementing and interfacing additional remedial actions (if necessary), and the ability to monitor effectiveness of the remedy.

- Administrative feasibility—Ability of the alternative to be coordinated with activities of other offices and agencies, and the potential for regulatory constraints to develop (e.g., uncovering buried cultural resources or encountering endangered species).

- Availability of services and materials—Availability of adequate off-INEEL treatment, storage, and disposal (TSD) facilities with sufficient capacity, availability of necessary equipment and specialists and provisions to ensure any necessary additional resources, availability of services and materials, and availability of prospective technologies.

4.1.2.5 Cost. The NCP (40 CFR 300.430[e][9][G]) requires assessment of expenditures for capital, operation, and maintenance costs required to complete each measure. Once these values have been identified and a present worth has been estimated for each alternative, comparative evaluations can be made.

Cost estimates presented in this report are based on preliminary descriptions of the alternative and do not include detailed engineering data. An estimate of this type, in accordance with EPA guidance

(EPA 2000), should be accurate between -30 and +50%. Cost estimates for each alternative include a contingency consisting of both scope and bid preparation considerations. Contingency values applied were alternative-specific, in accordance with EPA guidance (EPA 2000). In addition, the net present worth calculations assume a discount rate of 7%, consistent with current EPA guidelines.

Cost estimates were prepared from current information and are presented in FY 2002 dollars. Actual project costs will depend on final scope and design of the selected remedial action, the schedule of implementation, competitive market conditions, and other variables. However, most of these factors would not affect the relative cost differences between alternatives. Detailed cost estimates for each alternative are provided in Appendix D.

4.1.3 Modifying Criteria

4.1.3.1 State Acceptance. The NCP (40 CFR 300.430[e][9][H]) addresses the technical and administrative issues and concerns a state may have about each alternative. This criterion is addressed following State of Idaho review of the WAG 7 RI/FS and proposed plan.

4.1.3.2 Community Acceptance. The NCP (40 CFR 300.430[e][9][I]) requires that an assessment be conducted of issues and concerns the public may have about each alternative. This criterion is addressed following public review of the WAG 7 proposed plan.

4.2 Alternative 1—No Action

4.2.1 Alternative Description

Guidance specifies preparing and developing a No Action alternative to use as a baseline to compare with other alternatives (40 CFR 300.430[e][6]). Under the No Action alternative, no remedial action would be taken at the WAG 7 site beyond the current site-wide monitoring of environmental media. Buried waste would remain as it is and no future maintenance or institutional controls would be implemented to prevent access to the waste by human or ecological receptors. Costs for this alternative include long-term monitoring of groundwater, soil, air, and other environmental media for 100 years.

No Action Alternative Remediation Strategy

Existing site conditions will remain unchanged. No action would be taken to reduce contaminant mobility, toxicity, or volume.

Key Element:
Long-term monitoring.

A summary of the proposed monitoring program is presented in Table 4-3. This program has been developed to provide an assessment for protectiveness with consideration given to the RAOs and current environmental monitoring practices. As shown in the table, groundwater monitoring involves a staged quarterly, semiannual, and annual program to be conducted through the existing groundwater monitoring network. No upgrades or improvements to groundwater-monitoring are included under this alternative. Similarly, vadose zone monitoring would be conducted with existing lysimeters and vapor ports. In addition, this alternative includes periodic site inspections to identify biotic intrusion problems. A review of monitoring requirements would occur every 5 years to evaluate the effectiveness of the No Action alternative.

4.2.2 Screening Assessment

In the following sections, an assessment is provided of the ability of the No Action alternative to satisfy the two threshold criteria and the five balancing criteria described in Section 4.1.

Table 4-3. Projected monitoring requirements of the No Action alternative.

Media	Assumptions
Groundwater	Sample 16 locations quarterly for 2 years; semiannually for following 3 years; annually for remaining 95 years.
Vadose zone	Annual sampling of lysimeters (37); vapor port (20) sampling quarterly for 5 years and annually for remaining 95 years.
Surface water	Sample two points every 5 years for 100 years.
Air	Sample four existing air monitors annually for 100 years; annual radiological monitoring.
Biological	Animal intrusion monitoring conducted twice during first 5-year period and once every following 5 years for a total of 100 years.

4.2.2.1 Overall Protection of Human Health and the Environment (Threshold Criterion). The No Action alternative would not protect human health and the environment. As identified in the ABRA, existing conditions at the site pose and would continue to pose a risk to human health and the environment through a number of projected pathways, including direct contact and groundwater usage. Only through radioactive decay or other natural processes would risk levels be reduced.

4.2.2.2 Compliance with Applicable or Relevant and Appropriate Requirements (Threshold Criterion). The No Action alternative includes long-term monitoring with no additional remedial actions implemented at the WAG 7 site. The EPA (1991) directive indicates that ARARs are not applicable to a no-action alternative. However, because monitoring would continue under this alternative, compliance with ARARs is addressed by considering chemical-, location-, and action-specific ARARs and TBC requirements. For the No Action alternative, it is assumed that long-term environmental monitoring would be implemented under an existing program without changes to that program. Appendix A presents a comprehensive summary of the potential ARARs that have been identified.

Table 4-4 provides an evaluation summary of the major substantive ARARs for the No Action alternative. Each requirement is identified by (1) type (i.e., chemical-, location-, or action-specific), (2) relevance (i.e., applicable, relevant and appropriate, or TBC), and (3) regulatory source citation. The table also presents a conclusion as to whether the proposed alternative would satisfy a corresponding requirement.

Table 4-4. Summary of the regulatory compliance evaluation for the No Action alternative.

ARAR or TBC	Type	Relevance	Citation	Meets Evaluation?
Radiation protection of the public and the environment	Chemical Action	TBC	DOE Order 5400.5	No
Idaho control of fugitive dust emissions	Chemical Action	AR	IDAPA 58.01.01.650, .651	No
Radioactive waste management	Action	TBC	DOE Order 435.1	No

AR = applicable requirement
ARAR = applicable or relevant and appropriate requirement
TBC = to-be-considered requirement

4.2.2.2.1 Chemical-Specific (Applicable or Relevant and Appropriate Requirements)—As discussed in Section 2, chemical criteria are based on the RAOs established for this PERA including inhibiting ingestion of and direct exposure to COCs in soil and waste and inhibiting migration of COCs to groundwater. The No Action alternative would not meet the RAOs because this alternative does not propose any action to reduce, control, or mitigate exposure from radiological or hazardous contaminants. The alternative would not comply with the Idaho rules for control of fugitive dust emissions (IDAPA 58.01.01.650, .651) that apply to any source of fugitive dust. Because no effort would be made to mitigate or control dust that might occur over time, this alternative might result in noncompliance with this standard. In addition, contaminants would continue to leach from the site at rates that would affect groundwater and pose potential future risks to human health. As discussed in Section 2.2, this analysis focuses on mitigating contaminants in the source term. Technology applications for remediating area groundwater are not directly addressed. Therefore, criteria (e.g., MCLs and the maximum contaminant level goals [MCLGs]) established under the "National Primary Drinking Water Standards" (40 CFR 141) and the groundwater quality standards, as adopted by the "Ground Water Quality Rule" (IDAPA 58.01.11), were not considered as ARARs for OU7-13/14. However, remedial actions at WAG 7 must take into consideration these criteria and address estimated groundwater risks to ensure compliance with the RAOs.

4.2.2.2.2 Location-Specific (Applicable or Relevant and Appropriate Requirements)—Evaluating location-specific ARARs is impossible because the No Action alternative does not propose any action.

4.2.2.2.3 Action-Specific (Applicable or Relevant and Appropriate Requirements)—The No Action alternative does not propose any action to reduce, control, or mitigate exposure from radioactive and hazardous chemical contaminants. Consequently, compliance with action-specific ARARs is not specifically pertinent. A possible exception may be failure of the alternative to fulfill DOE orders that are TBCs (i.e., DOE Order 435.1, "Radioactive Waste Management," and 5400.5, "Radiation Protection of the Public and the Environment.") The DOE Order 435.1 establishes requirements and specific responsibilities for implementing radioactive waste management practices applicable to all DOE radioactive waste. This order specifies that protecting the public and the environment from radiation must comply with the criteria and requirements of DOE Order 5400.5. The No Action alternative would not (1) fulfill TBCs, (2) mitigate possible health risks projected for current workers, potential future residents, and environmental receptors, and (3) achieve specific waste management standards and criteria.

4.2.2.3 Long-Term Effectiveness and Permanence (Balancing Criterion). The No Action alternative does not provide for long-term control of human and ecological exposure to waste within the WAG 7 boundary. As documented in the ABRA, modeling shows that migrating contaminants from the waste to the surface and groundwater will result in unacceptable carcinogenic risk (greater than 1E-04) and noncarcinogenic hazards (combined hazard index greater than 2) to future human receptors. Ecological risks also are unacceptable, with a resulting hazard quotient greater than 10. The magnitude of risk for the No Action alternative is significant to future receptors because exposure to the waste and any resulting contaminated soil would not be inhibited.

4.2.2.4 Reducing Toxicity, Mobility, or Volume Through Treatment (Balancing Criterion). The No Action alternative does not reduce the toxicity, mobility, or volume of contaminants at the site.

4.2.2.5 Short-Term Effectiveness (Balancing Criterion). Because no further remedial actions would be taken, this alternative could be readily implemented without additional risk to the community, workers, or environment. No specialized equipment, personnel, or services would be required to implement the future monitoring program required for the No Action alternative. Further, there would be no short-term adverse impacts to socioeconomic or cultural resources because of remedial actions. Should additional monitoring wells be required in the future in or around WAG 7, any administrative, engineering, and PPE measures could be used to ensure that employees are properly protected.

4.2.2.6 Implementability (Balancing Criterion). Because no further action would be taken under this alternative, no difficulties or uncertainties with construction would arise and no specialized equipment, personnel, or services would be required. All monitoring techniques are technically and administratively implementable and are conducted routinely. However, whether a long-term monitoring program could be enforced and maintained during the full duration of the projected site risks, as identified in the ABRA, is questionable.

4.2.2.7 Cost (Balancing Criterion). Because no capital costs are budgeted, total project costs associated with this No Action alternative primarily involve the long-term environmental monitoring program described previously. As presented in Appendix D, total monitoring and management costs for a period of 100 years are projected to be approximately $38.5 million. The net present value of the No Action alternative is estimated at $9.6 million. The costs include an estimated 20% contingency. A summary of the costs is provided in Table 4-5.

Table 4-5. Estimated costs for the No Action alternative with contingency.

Cost Element	Total Costs ($M)	Net Present Value ($M)
Capital costs	None	None
Operating and maintenance costs		
Fencing and signage	0.3	—
Monitoring	33.7	—
Management	4.5	—
Total alternative costs	**38.5**	**9.6**

4.3 Alternative 2—Surface Barrier

4.3.1 Alternative Description

The Surface Barrier alternative consists of institutional controls, physical barriers, and long-term operation and maintenance. The primary technology associated with this alternative is the long-term multilayer cover system. Layers of the cover would be designed not only to prevent human or ecological receptors from direct contact with the buried waste, but also to stabilize some contaminants in place and minimize migration through leaching, volatilization, or biotic uptake.

In addition to the primary technology, the Surface Barrier alternative includes implementing a number of supplemental

Surface Barrier Alternative Remediation Strategy

Isolation of the buried waste and reduction of contaminant migration through the placement of a long-term, low-permeability cover system.

Key Elements:
(1) In situ grouting at selected disposal sites
(2) In situ thermal treatment in areas with high levels of volatile organic compounds
(3) Pad A retrieval and reconfiguration
(4) Foundation stabilization
(5) Long-term multilayer cover
(6) Physical and administrative land-use restrictions
(7) Long-term monitoring and maintenance.

technologies to ensure compliance with the RAOs. In situ grouting would be applied to the waste disposal areas within the SDA to (1) treat contaminant-specific disposal areas where preliminary modeling indicates that the cap alone may be unable to adequately mitigate future groundwater risks and (2) stabilize the subsurface to prevent future subsidence that could damage the integrity of the cover system. For this alternative, ISG would be used to encapsulate waste within SVRs and specific areas within the trenches that contain C-14, I-129, Nb-94, and Tc-99. Distribution of this waste is depicted in Figure 3-4. Grouting would be extended into remaining pits and trenches as required to stabilize the cap subgrade. This general foundation stabilization step would be similar for all alternatives requiring a capping technology and would be conducted as described in Section 3.3 to ensure long-term stability of the cover system. This alternative also includes retrieving and placing Pad A waste into a more stable configuration within the SDA, as required to minimize potential for future subsidence.

Discussions about the basic elements of this alternative are provided in the following subsections.

4.3.1.1 Preconstruction Activities. These activities would include borrow-source investigations, a safety assessment, and mobilization and setup of equipment, supplies, and personnel. Primarily, borrow-source investigations would involve verifying the quantities of silt loam available at Spreading Areas A and B. Material at Spreading Area B proposed for use in the clay barrier layer would be sampled and tested to verify that it can be placed and compacted to achieve a very low permeability. If the material at Spreading Area B does not meet permeability requirements, other sources would need to be investigated, or additives (e.g., bentonite) considered for construction of the clay barrier layer.

4.3.1.2 Primary Technology—Long-Term Low-Permeability Cap. The multilayer, low-permeability cap covering the entire SDA would be designed in accordance with specifications developed for the ICDF landfill at the INEEL. The cap would consist of a grading fill layer, a gravel gas collection layer, a compacted clay layer, a geomembrane, a capillary barrier, a coarse-fractured basalt biotic barrier, coarse and fine gravel and sand filters, an engineered earth fill layer, a perimeter berm, a riprap armor layer on berm and barrier side slopes, and a vegetated topsoil layer on the surface. Figure 4-1 shows a typical section of the cap construction with the protective berm system. As shown in Figure 4-1, the perimeter berm would extend approximately 100 ft from the toe of the cover system and be designed to protect the waste disposal units during potential flood conditions. Grading fill would be placed over the disposal areas to integrate with the perimeter berm and facilitate lateral drainage of the individual cover layers.

The cap design incorporates continued operation of the OCVZ vapor vacuum extraction system. Concurrent with construction, wells and treatment units supporting the OCVZ system would be extended or relocated. In addition, a gas collection layer would be incorporated into the cap design to passively vent VOC releases from the buried waste.

The cap would be constructed in phases. The first phase would focus on constructing the ICDF barrier within the inactive portions of the SDA while maintaining access to ongoing LLW disposal activities in Pits 17 through 20. During the second construction phase, after closure of LLW disposal pits, the perimeter berm would be completed and the ICDF barrier extended over any remaining areas.

4.3.1.3 Supplemental Technologies. To provide compliance with the RAOs, this alternative would require implementing a number of supplemental technologies within the SDA to address contaminant-specific concerns and provide for long-term stability of the cover system.

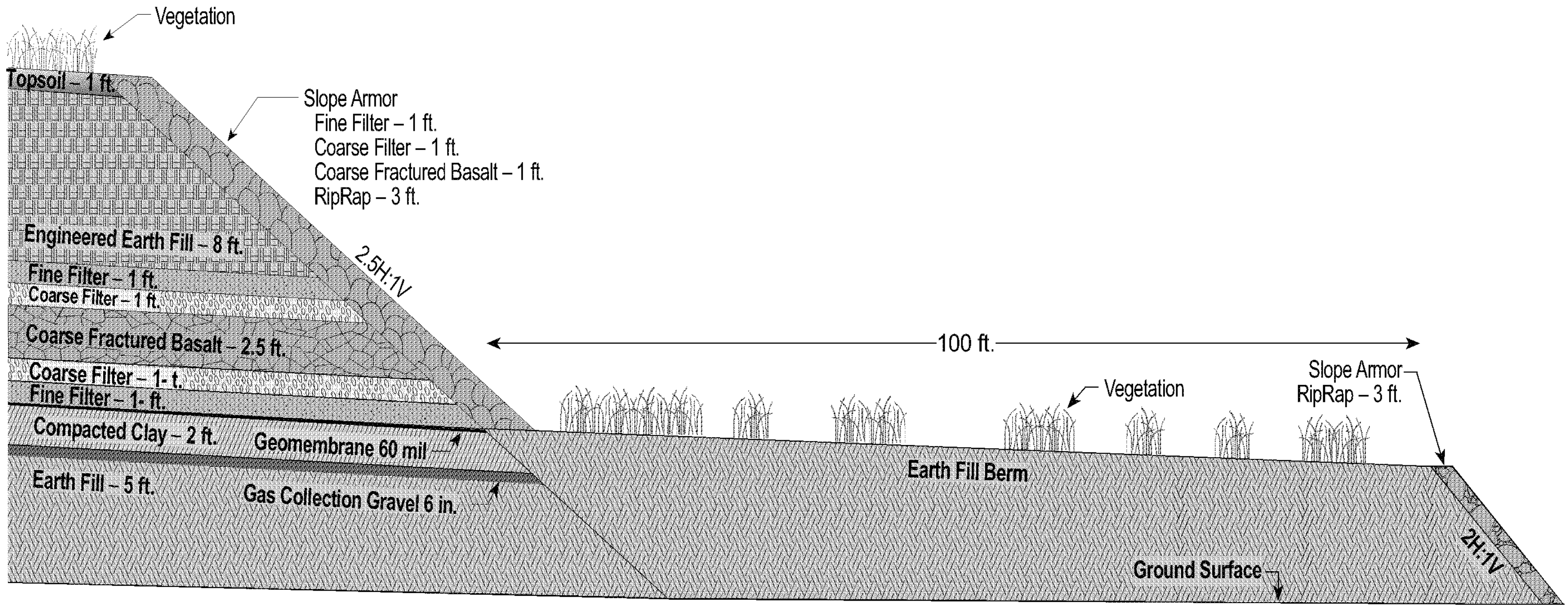

Figure 4-1. Cross-section view of the Surface Barrier alternative.

4.3.1.3.1 In Situ Organic Treatment—The OCVZ treatment system is currently in operation to remove VOCs, including CCl_4, from the vadose zone beneath the SDA, as discussed in Section 3.3.8. Carbon tetrachloride has been detected in area groundwater at concentrations slightly above drinking water standards and was identified in the ABRA as the contaminant posing the most imminent groundwater risk. Estimates of the SDA CCl_4 inventory have been revised upward (Miller and Varvel 2001), and adequacy of the present OCVZ system is currently being evaluated. Preliminary modeling results also have shown that even after putting the low-permeability ICDF cover in place, CCl_4 would continue to leach from the source term at a potentially unacceptable rate.

For these reasons, the Surface Barrier alternative has included implementing the ISTD technology to treat waste zones containing high concentrations of VOCs before constructing the cover system. Disposal records indicate that CCl_4 is contained primarily in the oil waste (Series 743 sludge) received from the RFP. Distribution of this waste is depicted in Figure 3-8. For this alternative, it is projected that the ISTD technology would be applied over the extent of the Series 743 sludge disposals, a total area of approximately 5 acres.

In situ thermal desorption would employ an array of heated stainless steel pipe assemblies inserted in the ground on an 8 × 8-ft spacing to a depth of approximately 3 ft below the buried waste. Each assembly would include a sealed pipe containing an electrical resistance-heating element, a vented pipe used to extract gases, and thermocouples. Each extraction pipe would be connected to a pipe manifold that would convey gases to an off-gas treatment system. The pipe assemblies would be inserted into the ground using vibratory or hydraulic techniques. A more detailed discussion about implementing ISTD within the SDA is presented in Section 4.5.1.2. Determination of specific pretreatment requirements would be evaluated further during the design phase.

4.3.1.3.2 In Situ Grouting—Disposal units in the SDA would be grouted before construction of the low-permeability cap to (1) encapsulate and immobilize specific COC-bearing waste in situ and (2) stabilize the cover foundation for structural support. A detailed discussion of the implementation of ISG within the SDA is provided in Section 4.4 and in the supporting report (Armstrong, Arrenholz, Weidner 2002).

Activation and fission products, including C-14, I-129, Nb-94, and Tc-99, have been identified in the ABRA as COCs that exceed risk-based thresholds. Preliminary modeling results also indicate that even after putting the low-permeability ICDF cover in place, these mobile COCs would continue to leach from the source term and potentially affect area groundwater at unacceptable concentrations. The activation and fission product waste within the SDA is contained primarily in the SVRs and a number of locations within the LLW trenches (see Figure 3-4). To address the RAOs, this waste would be encapsulated in grout or other media to immobilize contaminants and reduce the infiltration of moisture around the waste. In the trench areas, grout would be injected on approximately 2-ft centers. Such a high density of injection points ensures that waste containers would be intersected and the contents mixed with high-pressure grout. Cementitious grouts have been shown to be effective waste forms for radioactive contaminants (e.g., C-14).

A similar approach would be used in the SVRs. Because the SVRs consist of a series of approximately 650 individual vaults arranged in 21 rows, grout would be injected at each vault rather than on the rigid grid used for pits and trenches. Soil vaults are (1) small, approximately 16-in. diameter, and (2) large, approximately 57-in. diameter, and they are arranged in long lines across a number of areas within the SDA. The grout injection lance likely would be inserted around the perimeter of each vault. Injected grout would surround the waste object(s) and fill any void space in the soil vault. Soil above and below the object(s) also would be grouted. As grouting of soil vaults has not been performed before, some field-testing would be necessary to ensure safe operations.

The pits and remaining areas within the SDA would be grouted for foundation stabilization using the modified grouting program discussed in Section 3.3.3. This grouting technique would fill readily accessible void spaces and minimize future subsidence problems.

4.3.1.3.3 Pad A Waste Preparation—For the Surface Barrier alternative the Pad A waste would be retrieved. Pad A is not in a configuration that could be easily capped and poses a potential subsidence problem following placing of the cover system. The Pad A waste area extends to an average height of 9 m(29.5 ft), and the cover is not stable enough to support heavy equipment. In addition, it is critical that future subsidence be prevented to avoid damage of the surface barrier and minimize future maintenance work. Owing to the unstable nature of the surface of the Pad A waste pile and potential design issues associated with incorporating the pile into the final cover system, waste and soil would be retrieved and reconfigured in a compacted layer within the center of the SDA before plac the final cover.

Pad A primarily contains TRU alpha-emitting radioisotopes with concentrations less than 10 nCi/g and radiation levels less than 200 mR/hour at the container's surface, though two shipments contained TRU waste at concentrations greater than 100 nCi/g (DOE-ID 1998). Containers of waste (i.e., drums and plywood boxes) are stacked and covered with soil. Each stack at Pad A consists of as many as 11 drums or five boxes. Drums are stacked horizontally in staggered layers and boxes are stacked around the periphery of the pad. Retrieving the Pad A waste would require building a containment structure to prevent contaminant releases during retrieval. A discussion of the retrieval process for Pad A is presented in Section 4.6.1.3.

4.3.1.3.4 Land-Use Restrictions—Institutional controls and physical barriers include restricting access by imposing deed restrictions and posting permanent markings and informational notices on the site. Land-use restrictions would further prohibit construction of water-supply wells and the future use of groundwater as a potable source within the immediate vicinity and downgradient of the site area. Physical barriers for this alternative would include a perimeter fence to restrict site access. These measures would prevent possible exposure to humans and ecological receptors.

4.3.1.3.5 Monitoring and Maintenance—The Surface Barrier alternative would require routine maintenance of the protective measures to ensure that features are inspected and repaired as necessary. In particular, maintenance to prevent or repair damage from erosion, burrowing animals, and deep-rooted plants. In addition, the Surface Barrier alternative would include long-term groundwater and air monitoring, conducted as part of the INEEL facility-wide monitoring. This program would be similar to that described for the No Action alternative (see Section 4.2.1), augmented by vegetation monitoring. Monitoring would be conducted annually for 5 years after placing the cover system and every 5 years thereafter. Periodic maintenance would be required to reestablish areas of failed vegetation. The cost estimate is based on performing these activities for 100 years, although maintenance in perpetuity would be required to ensure continued protection of human health and the environment.

4.3.1.4 Estimated Project Schedule. Figure 4-2 details the schedule for the tasks involved in the first phase of construction. The projected schedule shows that, with an approved ROD in 2005, the initial phase of cap construction could be completed by 2016, with an additional 2 years projected to establish the vegetative cover.

Active disposal at the SDA is projected to end by 2020. Then, the second phase of construction would cover the estimated remaining 5 acres. Because of the small size of this area, the cap could be constructed in a 2-year period, followed by an additional 2-year period to establish the vegetative cover.

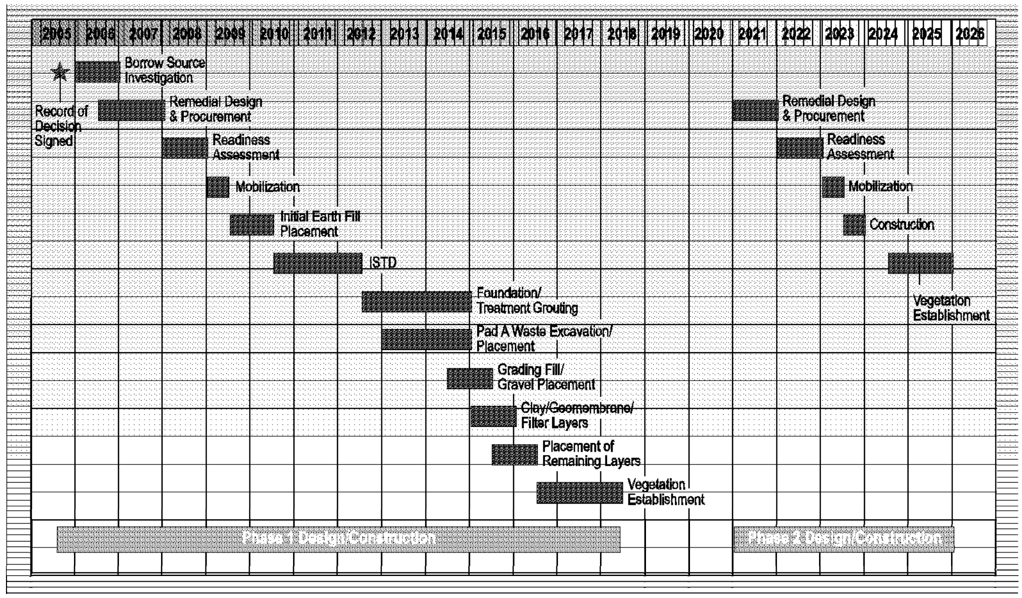

Figure 4-2. Schedule for tasks in the first phase of construction for the Surface Barrier alternative.

4.3.2 Screening Assessment

The following sections present and assess the ability of the Surface Barrier alternative to satisfy the two threshold and five balancing criteria described in Section 4.1.

4.3.2.1 Overall Protection of Human Health and the Environment (Threshold Criterion). This alternative is projected to provide for the long-term protection of human health and the environment. The multilayer, low-permeability cap would control and minimize contaminant migration by reducing surface water infiltration rates, thus impeding further release of contamination to the aquifer. Implementing the ISG technology would effectively stabilize activation and fission products within the SVRs and trenches. Implementing ISTD would provide for treating VOCs within the source term and minimize future requirements for the OCVZ system. In addition, the cap would effectively isolate buried waste, prevent ecological receptor exposures, prevent transport of contaminants by plants and animals, and prevent ingestion of, and direct exposure to COCs located at the waste sites.

4.3.2.2 Compliance with Applicable or Relevant and Appropriate Requirements (Threshold Criterion). The Surface Barrier alternative would cover buried waste at WAG 7 by installing and maintaining a long-term multilayer cover system. Therefore, the key ARARs for this alternative relate to containing buried waste over time. Additional ARARs for this alternative relate to the supplemental technologies required to satisfy the RAOs. Limited grouting also would be completed in the Surface Barrier alternative to encapsulate or stabilize waste in the SVRs and trenches where activation product material is disposed of. Foundation grouting to prevent cap subsidence would be performed for remaining waste disposal sites within the SDA. The ARARs identified for grouting (discussed in Section 4.4.2.3) also would apply to this remedy. The ARARs for ISTD, which would be applied in the high VOC areas, are identified in Section 4.5.2.3. The ARARs related to the retrieval action required for the Pad A waste are presented in Section 4.6.2.3.

The evaluation summary of the key ARARs for the Surface Barrier alternative, including limited ISG, ISTD, and RTD, is presented in Table 4-6. Each requirement is identified by type (i.e., chemical-, location-, or action-specific), relevance (i.e., applicable, relevant and appropriate, or TBC), and regulatory source citation. The table also presents a conclusion as to whether the proposed alternative would satisfy a corresponding requirement. Appendix A presents a comprehensive summary of the potential ARARs identified for the WAG 7 feasibility study.

4.3.2.2.1 Chemical-Specific (Applicable or Relevant and Appropriate Requirements)—As described in this PERA, the Surface Barrier alternative would meet RAOs for direct contact because the protective layers of the surface barrier would prevent exposure to underlying soil and waste by any inadvertent human intruders and ecological receptors.

Table 4-6. Regulatory compliance evaluation summary for the Surface Barrier alternative.

ARAR or TBC	Type	Relevancy[a]	Citation	Meets Evaluation?
Radiation protection of the public and the environment	Chemical Action	TBC	DOE Order 5400.5	Yes
Idaho toxic air pollutants	Chemical	A	IDAPA 58.01.01.585 and .586	Yes
Idaho ambient air quality standards for specific air pollutants	Chemical	A	IDAPA 58.01.01.577	Yes
National emission standards for hazardous air pollutants	Chemical	A	40 CFR 61	Yes
Native American graves protection and repatriation regulations	Location	A	43 CFR 10	Yes—if encountered
Preservation of historic, prehistoric, and archeological data	Location	A	36 CFR 800 and 40 CFR 6.301(b) and (c)	Yes—if encountered
Protection of archaeological resources	Location	A	43 CFR 7	Yes—if encountered
Preservation of historical sites	Location	A	Idaho Statute 67-4601 et seq. and Idaho State Historical Statute 67-4101 et seq.	Yes—if encountered
Compliance with environmental review requirements for floodplains and wetlands	Location	A	10 CFR 1022	Yes
Protection of floodplains	Location	RA	Executive Order 11988; 40 CFR 6.302(b); 40 CFR 6 Appendix A	Yes
Remediation waste management sites located within floodplains	Location	A	40 CFR 264.18(b)	Yes
Location standards for TSD facilities located within floodplains	Location	A	40 CFR 264.1(j)(7)	Yes
Idaho groundwater quality rule	Action	A	IDAPA 58.01.11.006	Yes[b]
Standards for owners and operators of TSD facilities—general groundwater monitoring requirements	Action	A	40 CFR 264.97	Yes[b]
Standards for owners and operators of TSD facilities—location of facilities	Action	A	IDAPA 58.01.05.2 (40 CFR 270.14)	Yes
Standards for owners and operators of TSD facilities—closure and postclosure	Action	RA	IDAPA 58.01.05 (40 CFR 264 Subpart G)	Yes

Table 4-6. (continued).

ARAR or TBC	Type	Relevancy[a]	Citation	Meets Evaluation?
Standards for owners and operators of TSD facilities—landfills	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart N)	Yes[b]
Standards for owners and operators of TSD facilities—air emission standards for process vents	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart AA)	Yes
Standards for owners and operators of TSD facilities—air emission standards for equipment leaks	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart BB)	Yes
Standards for owners and operators of TSD facilities—remediation waste management rules	Action	A	IDAPA 58.01.05 (40 CFR 264.1[j][1] through [13])	Yes
Idaho control of fugitive dust emissions	Action	A	IDAPA 58.01.01.650, .651	Yes
National ambient air quality standards	Action	A	40 CFR 50	Yes
National Pollutant Discharge Elimination System	Action	RA	40 CFR 122.26	Yes
Radioactive waste management	Action	TBC	DOE Order 435.1	Yes

a. A = applicable requirement, RA = relevant and appropriate requirement, TBC = to-be-considered requirement
b. Evaluation criteria met, not including the vadose zone contribution.
ARAR = applicable or relevant and appropriate requirements
CFR = *Code of Federal Regulations*
DOE = U.S. Department of Energy
IDAPA = Idaho Administrative Procedures Act
TSD = treatment, storage, and disposal

Groundwater in the vicinity of WAG 7 comprises the Snake River Plain Aquifer. This sole-source aquifer is a source of potable water. Consequently, though drinking water standards (IDAPA 58.01.11; 40 CFR 141) were not identified as ARARs, remedial actions for WAG 7 must take into consideration these criteria along with site-specific risk-based concentrations to ensure compliance with the RAOs. Depth to the water table is approximately 580 ft. As designed, this alternative would significantly reduce infiltration and limit mobility of COCs from the source, satisfy RAOs that protect groundwater, and comply with applicable state and federal groundwater criteria (e.g., MCLs and MCLGs). This alternative would not address existing contamination in the vadose zone.

The Clean Air Act requires each state to identify areas that have not attained National Ambient Air Quality Standards (NAAQS) for criteria air pollutants. According to the EPA Green Book and the most recent listing designating nonattainment areas for criteria pollutants (EPA 2001), the State of Idaho (including the INEEL and WAG 7) is not located within a designated nonattainment area for any criteria pollutant. Consequently, no current substantive requirements for new sources or modifications to existing air-emission point sources would affect or apply to the Surface Barrier alternative. When constructed, the surface barrier would prevent the emission of radionuclides higher than Idaho standards for the control of air pollution and DOE Order 5400.5.

In addition, the chemical-specific requirements of state and federal air quality standards would be met during both construction and remediation. Idaho state requirements include controlling toxic air pollutants (IDAPA 58.01.01.585 and .586), ambient air quality standards for specific air pollutants (e.g., as particulate matter [IDAPA 58.01.01.577], and emission of fugitive dusts [IDAPA 58.01.01.650]).

Federal requirements include NESHAPs (40 CFR 61) (e.g., radionuclides) and NAAQS (40 CFR 50) (e.g., particulate matter).

4.3.2.2.2 Location-Specific (Applicable or Relevant and Appropriate Requirements)—Studies of the INEEL conclude that all archeological material and data are related to surficial areas and do not meet the criteria for listing under any repatriation or historical site regulations (EG&G 1992). However, if material for the surface barrier is excavated from an off-INEEL borrow area, and if regulated artifacts or sites are encountered, applicable federal and state preservation requirements would be applicable and would be met. These include the following:

- Native American Graves Protection and Repatriation Regulations (43 CFR 10)
- Protection of Historic Properties (36 CFR 800 and 40 CFR 6.301[b])
- Preservation of Historical Sites (Idaho Statute 67-4601 et seq.).

Waste Area Group 7 is not designated as a floodplain, though flooding attributed to unseasonable snowmelts occurred in 1962, 1969, and 1982. Conditions suggest that floodplain protection measures are applicable or relevant and appropriate, as indicated in Table 4-6. Included are requirements for federal agencies to comply with floodplain management (10 CFR 1022), to protect floodplains (40 CFR 6), and to implement protective measures at remediation waste sites (40 CFR 264.1[j][7]) and RCRA-permitted facilities (40 CFR 264.18 [b]). The design of the surface barrier would meet these requirements and would include (1) appropriate engineering controls to prevent washout of any hazardous waste by a 100-year flood event required by RCRA 40 CFR 264.1[j][7] for remediation waste sites or (2) the location standards for TSD facilities required by RCRA (40 CFR 264.18[b]).

4.3.2.2.3 Action-Specific (Applicable or Relevant and Appropriate Requirements)—For RCRA requirements to be applicable to a CERCLA site, materials must be listed or exhibit a characteristic of hazardous waste. Active generation or placement of hazardous waste is not proposed for the Surface Barrier alternative. However, RCRA "General Groundwater Monitoring Requirements" (40 CFR 264.97) that use monitoring wells to detect COCs in the underlying aquifer are applicable to this alternative. Provisions for groundwater monitoring would be included in the alternative.

Furthermore, because the Surface Barrier alternative leaves waste in place, RCRA Subtitle C requirements for closure and postclosure (40 CFR 264 Subpart G) may be relevant and appropriate because the SDA is not a new or existing RCRA-regulated unit. The RCRA requirements for landfills (40 CFR 264 Subpart N) and remediation waste management sites (40 CFR 264.1[j]) are applicable for designing and operating the surface barrier. These requirements are adopted by reference in the State of Idaho "Rules and Standards for Hazardous Waste" (IDAPA 58.01.05). The design, construction, and operation of the surface barrier would meet these substantive state requirements. In addition, the RCRA Subtitle C requirements for air emission standards for process vents (40 CFR 264 Subpart AA) and equipment leaks (40 CFR 264 Subpart BB) may be applicable for some equipment used during ISTD operations, if it is possible that their emissions contain levels of restricted hazardous volatile waste above established thresholds. If applicable, these requirements would be met by using appropriate engineering controls.

Organic vapors that accumulate beneath the surface barrier would be collected, removed, and treated by the OU 7-08 active OCVZ treatment system at the RWMC. The EPA Office of Air Quality Planning and Standards is developing a new maximum achievable control technology (MACT) for the remediation site source category. This MACT, projected to be effective after 2002, would apply to remediation sites that are major sources of organic hazardous air pollutants during remediation activities.

If applicable to CERCLA sites, all vents, remedial material management units, and associated equipment components involved in the remedial activity could require emission controls.

For RCRA LDR treatment standards (40 CFR 268) to apply to waste, the placement of restricted hazardous waste must occur. For the Surface Barrier alternative, the only potential placement activity would be associated with retrieving waste from reconfiguring Pad A. The RCRA generator requirements for hazardous waste determination and management (40 CFR 262.11) would be applicable because potentially hazardous material may be generated during retrieval. Furthermore, applicable requirements would prohibit placing restricted RCRA-hazardous waste in land-based units (e.g., landfills) until it has been treated to standards protective for disposal (40 CFR 268; IDAPA 58.01.05.011). The WAG 7 area will be defined as an area of contamination (AOC). Because it is assumed that the AOC concept would be used when retrieving and handling the Pad A waste, consolidation and movement would occur without triggering RCRA Subtitle C requirements (e.g., LDRs).

Institutional controls are often included with remedies to enhance long-term management protection. These controls supplement engineered remedies (40 CFR 300.430[a][1]). Institutional controls, including security measures, access controls, fencing, and land-use restrictions, are components of the Surface Barrier alternative. These controls would help prevent possible exposure to waste by human intruders and biota. The institutional controls also would meet applicable DOE requirements for residual radioactivity left in place, including the related provisions of DOE Order 5400.5.

Storm water discharge requirements from "National Pollutant Discharge Elimination System" (NPDES) (40 CFR 122.26) would be considered during design and operation of the surface barrier. However, best management practices would be implemented during construction and operation of this alternative for storm water control, road construction, waste management, and other activities that support and relate to the remedy, as appropriate. In addition, DOE requirements (identified as TBCs) for the protection of human health would be met during these remedial activities, including as low as reasonably achievable (ALARA) exposures to radioactivity. Requirements of DOE Order 435.1 would be met. This order specifies that all DOE radioactive waste is to be managed in a manner that protects workers, public health and safety, and the environment.

4.3.2.3 Long-Term Effectiveness and Permanence (Balancing Criterion). The Surface Barrier alternative would (1) reduce risk by inhibiting water infiltration through waste, thereby impeding further release of contamination to the aquifer, (2) prevent ecological intrusion and deter human intrusion into the waste, (3) eliminate risk from direct radiation exposure, and (4) protect the waste from wind and water erosion. The cap would eliminate the potential for spread of contamination on the surface and in the air. Grouting SVRs and trenches would immobilize fission and activation products (e.g., C-14, I-129, Nb-94, and Tc-99). In addition, the alternative includes ISTD in high VOC areas to minimize future CCl_4 releases from the source term and to reduce operational requirements for the OCVZ system. Risk modeling shows this alternative would be effective in reducing contaminant migration and groundwater ingestion risk attributed to COCs in the burial zone to acceptable levels.

Though this alternative would be effective at minimizing future risk, it is assumed that some COCs would be released before remedial action could take place. The amount released to date and current rates of release are not known with certainty. However, the ABRA (Holdren et al. 2002) indicates that the preremediation release might result in groundwater contamination posing a risk greater than 1E-04. Modeling indicates that this risk would peak by 2110 and could extend beyond the boundary of the SDA for a distance of approximately 460 to 600 m (1,500 to 2,000 ft). Therefore, this alternative could require institutional controls that prohibit using groundwater within this buffer zone around the SDA.

In addition to the prohibition on groundwater use within a buffer zone around the SDA, other institutional controls would be required to ensure RAOs are met and maintained. Land-use restrictions would be required to prevent development, excavation, or drilling on and near the SDA. Frequent inspection and maintenance of the surface barrier would be required. The barrier would have to be reconstructed every 500 to 1,000 years. Environmental monitoring would be required to assess the continued effectiveness of Surface Barrier alternative in preventing migration of contaminants to the aquifer.

4.3.2.3.1 Risk Modeling Assumptions—For the Surface Barrier alternative, water was assumed to infiltrate the barrier system at a rate of 0.114 cm/year. In the grouted SVRs and selected trenches, contaminant releases from the grout were conservatively assumed to occur by diffusion from within 2-ft diameter grout columns. These columns would be formed by injecting grout into the waste site to create columnar monoliths (see Section 4.2.5.1). For modeling purposes, the surface available for leaching was assumed to be the outside surface of the 2-ft-diameter columns. This is based on a conservative assumption that the points of contact between columns might be a zone of weakness where cracks could form. Realistically, the surface area available for leaching would probably be much smaller, but few data are available to support an accurate prediction of the extent of cracking that would form in grouted waste over long periods of time.

The DUST-MS model assumed that the infiltrating water would flow through the columnar joints in the grout at volumetric rates equal to the surface area of the treated area multiplied by the infiltration rate. The volume of water contacting the waste in a given time was assumed to dissolve contaminants up to their solubility limits. Concentrations of contaminants released from the source term were input to the TETRAD model to estimate groundwater concentrations and drinking-water risk.

4.3.2.3.2 Magnitude of Residual Risk—The magnitude of residual risk associated with the Surface Barrier alternative is illustrated in Figure 4-3. This figure shows two risk projections: (1) risk associated with postremediation release of contaminants from the SDA source term only, and (2) total risk represented by release of source-term contaminants plus postulated contamination in the vadose zone before the remedial action. The risks represent exposure at the point of maximum groundwater contamination. For results that include the postulated contamination in the vadose zone, this location lies

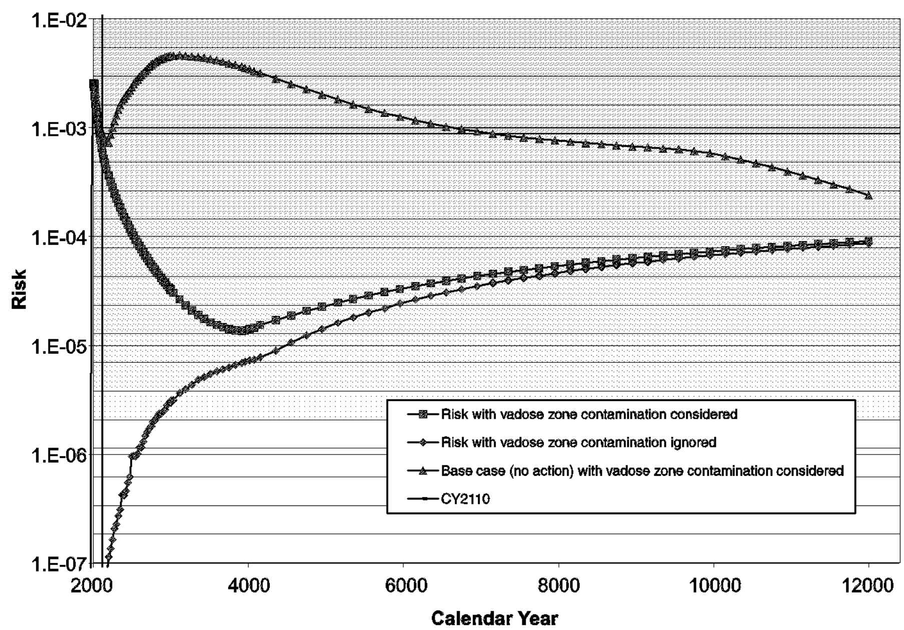

Figure 4-3. Carcinogenic risk for the Surface Barrier alternative.

at the southern edge of the SDA. Modeling shows that near-term risks are dominated by COCs that may already have been released to the vadose zone. However, considerable uncertainty remains because the mass of potential contaminants in the vadose zone and rates of release are not known.

As shown in Figure 4-3, carcinogenic risk associated with postremediation release of contaminants (i.e., preremediation vadose zone contamination neglected) reaches approximately 1E-05 in 2,000 years and then continues to rise at a slower rate, reaching a maximum of approximately 9E-05 in 10,000 years. Carbon-14 accounts for approximately 80% of the risk in 2,000 years. Technetium-99 and I-129 are other significant contributors. After 1,000 years, uranium isotopes dominate risk.

Figure 4-4 shows the residual noncarcinogenic hazard for the Surface Barrier alternative. The risk modeling indicates that the hazard index attributable to postremediation contaminant release under this alternative would be less than 1.0. The simulated hazard index peaks at 0.4 in approximately 2,500 years and then it decreases in subsequent years.

In both the carcinogenic and noncarcinogenic risk curves shown in Figures 4-3 and 4-4, the potential influence on risk levels caused by potential contaminants previously released from the source term to the underlying vadose zone are presented. As shown for the carcinogenic risks, effects of potential contaminants released to the vadose zone before remediation result in cumulative groundwater risk greater than 1E-07 for a zone that extends 460 m (1,500 ft) beyond the SDA boundary.

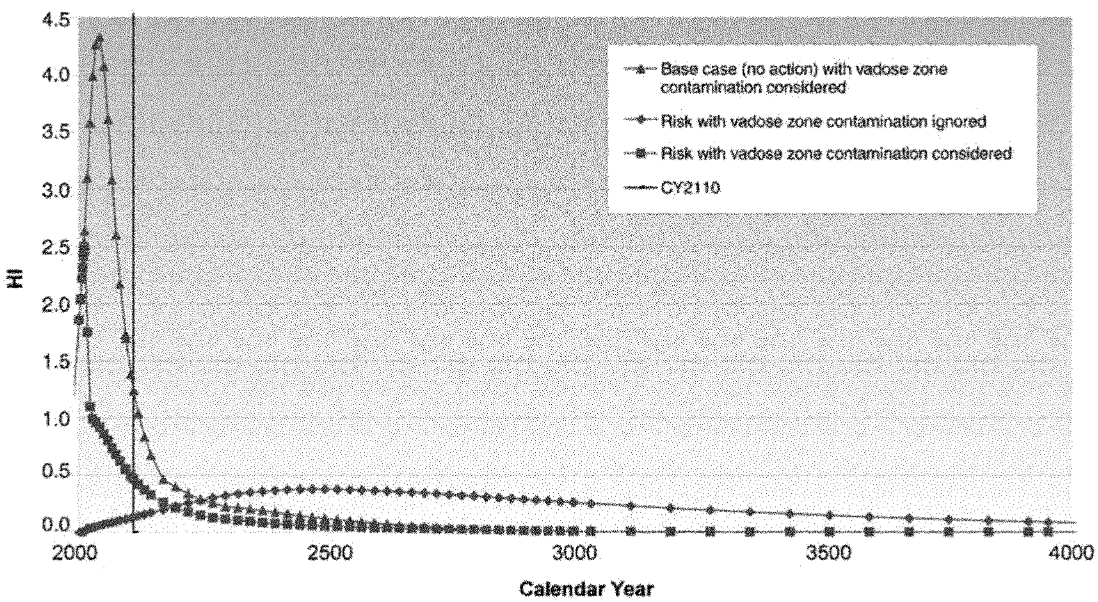

Figure 4-4. Noncarcinogenic hazard for the Surface Barrier alternative.

4.3.2.3.3 Adequacy of Reliability and Controls—Monitoring and maintenance of the surface barrier would be required in perpetuity to assure the effectiveness and permanence of the remedy. High-density polyethylene geomembranes have a limited life. Subsidence of underlying waste caused by consolidation of the waste may cause settlement and compromise the effectiveness of the barrier over time. Regular monitoring (e.g., visual inspections and surface elevation surveys) would be performed to detect compromises in the integrity or effectiveness of the barrier. The barrier would be maintained and repaired as required to achieve the original performance standards. Because of the required life span of the remedy, portions of the barrier would require repair or periodic reconstruction, and the entire barrier would be replaced once every 500 to 1,000 years.

In addition to monitoring, maintenance, and periodic replacement, the long-term reliability and performance of the barrier would be assessed through post—remediation monitoring of groundwater, the vadose zone, air, animals, and surface vegetation.

To ensure protectiveness, active institutional controls would be required to limit land-use activities near the SDA. A prohibition on drilling and using groundwater within a buffer zone around the SDA would have to be enforced. Access controls would have to be implemented and maintained in perpetuity to prevent intrusion into the waste.

4.3.2.3.4 Summary of Long-Term Effectiveness—Fate and transport modeling indicates that the remedial action would control future releases from the source term to the degree that the incremental postremediation peak carcinogenic risk would be less than 1E-04 and the hazard index would be less than 1.0 for the groundwater ingestion pathway. Appropriate institutional control and operation and maintenance programs, plus periodic barrier repair and replacement, would provide adequate and reliable long-term control of the waste. Should the postulated contamination in the vadose zone at the time of remediation cause groundwater contamination to exceed health-based levels in a zone beyond the boundary of the SDA, institutional controls would be required to prevent access to, and use of, any contaminated groundwater. Therefore, the Surface Barrier alternative is an effective and permanent remedy.

4.3.2.4 Reduction in Toxicity, Mobility, or Volume Through Treatment (Balancing Criterion). The contaminant technology does not include treatment or waste removal to reduce the toxicity, mobility, or volume of contaminants. However, placing the surface barrier would inhibit contaminants from migrating and minimize potential exposure and impacts to groundwater. For this alternative, the mobility of the activation and fission products (i.e., C-14, I-129, Nb-94, and Tc-99) in the SVRs and trenches would be reduced by using ISG. Further, implementing ISTD in high organics areas would remove and destroy VOCs, thus reducing the volume of VOCs within the source term.

4.3.2.5 Short-Term Effectiveness (Balancing Criterion). The key components of the Surface Barrier alternative's short-term effectiveness entail the following:

4.3.2.5.1 Protecting the Community During Remedial Actions—This alternative could be readily implemented with minimal risk and impact to the public and INEEL workers, although increased traffic at the INEEL during borrow-material acquisition is anticipated. If borrow material is obtained off the INEEL, increased traffic would affect neighboring communities. Traffic control plans would be developed to minimize the impact and potential increase in transportation risk to the public and the INEEL.

Most materials required for cap construction would be obtainable from borrow sources within the INEEL boundaries, but a source off the INEEL could be required for the cobble material.

4.3.2.5.2 Protecting Workers During Remedial Actions—Using appropriate PPE, engineering controls, and adherence to INEEL health and safety protocols, this alternative could be readily implemented with moderate risk and impact to workers. Remediation workers could potentially be exposed to radionuclides during site-preparation activities (e.g., subsurface stabilization and cap construction). Chemical and radiological hazards from direct ionizing radiation exposure, inhalation exposures, and contact exposures from beta sources would be mitigated through adherence to DOE and INEEL health and safety protocols. Earth-moving equipment modified with positive-pressure ventilation-system cabs and HEPA filters could be used at the INEEL to minimize exposure to radioactively contaminated areas. The barrier material in the lowermost layer(s) would add sufficient shielding throughout the remainder of construction activities.

A report prepared in support of this PERA (Schofield 2002) estimated the risk to workers associated with constructing the surface barrier. The analysis was conducted assuming a potentially worst-case condition in which all RFP waste is classified as TRU waste. The evaluation considered direct external radiation exposure and exposure to mechanical injuries for remediation workers. No risks to the public were projected for this alternative because no off-INEEL transportation of hazardous material is assumed. Estimated risks are listed below:

- Cancer = 1.55
- Injury = 84.7
- Fatality risk = 0.19.

As shown, the evaluation predicts that during implementing the Surface Barrier alternative, one to two workers would develop cancer caused by exposure to hazardous substances, including radioactive material and radiation fields. This evaluation conservatively assumes the same crew would be involved throughout the duration of the project. It is also estimated that approximately 85 injury accidents would occur during implementation of this alternative. The projection for fatality accidents is less than one.

The environmental monitoring component of this alternative would involve currently existing procedures that use engineering, administrative, and PPE measures to ensure worker protection during monitoring activities. In the event that the existing monitoring network was expanded as part of this alternative, engineering, administrative, and PPE measures would be used to protect workers during installation.

In accordance with DOE orders, construction activities would be performed in accordance with the ALARA approach for protection from radiation.

4.3.2.5.3 Environmental Impacts Associated with Construction—Environmental impacts associated with the Surface Barrier alternative include potential particulate emissions resulting from construction activities and increased construction-related traffic. Particulate emissions would be controlled with applicable dust-suppression techniques.

4.3.2.5.4 Time Until Remedial Action Objectives are Achieved—Preliminary project schedules estimate that the surface barrier (Phase I) could be completed within 11 years of an approved ROD. An additional 7 years would be required to complete construction of the surface barrier over the active disposal cells.

4.3.2.6 Implementability (Balancing Criterion). Key components of the Surface Barrier alternative's implementability include elements described in the following subsections.

4.3.2.6.1 Technical Feasibility—Technologies associated with implementing the Surface Barrier alternative are available and have been demonstrated previously at the INEEL and other sites. No known site-specific features would inhibit constructing a cap, and the required construction technology, services, and specialists would be readily available. Construction would involve standard techniques and earthwork equipment. In addition, similar caps have been successfully constructed at other DOE facilities.

Though the ICDF cover design has not yet been implemented at the INEEL, the cap is designed to use natural material readily available near the INEEL.

Major implementability issues associated with this alternative would be (1) the amount of subsidence that could occur without damaging the cover and (2) determining the mitigating measures to be taken before the cover is constructed. Subsidence is a well-documented, annual occurrence at the SDA. For example, a visual inspection of the SDA performed in April 1999 identified 13 subsidences across a number of pits and trenches. Subsidences ranged from 8 to 300 ft long, 4 to 37 ft wide, and 8 in. to 12 ft deep. Average subsidence length was 60 ft, average width was 15 ft, and average depth of the deepest points in a subsidence was 3 ft. However, subsidences as deep as 12 ft have been observed.

Though modern geosynthetics (e.g., low linear polyethylene) have the high tensile strength and flexibility to accommodate substantial settling, long-lived, low-permeability caps generally require a stabilized foundation. Even if the cover material could bridge subsidences, sagging and eventual collapse would be expected over long periods. The low-permeability cap design would require a stable foundation to preserve the integrity of the infiltration-inhibiting layers. The substantial subsidence currently being experienced could reduce the effectiveness of the cap and would be difficult to repair, because of the layered nature of the design. Methods to control subsidence would need to be developed and implemented before constructing the cap, and the actual foundation requirements would have to be developed as part of remedial design. Presently, consideration is given in this PERA for applying a grouting program to stabilize the foundation area within the cap footprint. However, during final design, other methods, such as dynamic compaction and preloading, could be adopted.

Though constructing the surface barrier would involve standard industry practices, the required mitigation of the potential landfill subsidence would complicate implementation of the alternative. The INEEL-developed nonreplacement jet grouting technology has been demonstrated on small scale but not on a large and complex site (e.g., the SDA) (Armstrong, Arrenholz, Weidner 2002).

Retrieving and treating Pad A waste is technically feasible. Waste is assumed to be primarily low-level with a minor amount of TRU. No hazards (e.g., explosives or highly flammable materials) have been identified.

4.3.2.6.2 Administrative Feasibility—Though most actions within this alternative are implemented under CERCLA and thus would not require permits, substantive provision of permits that would otherwise be required are identified as ARARs. Any selected remedial alternative would be required to demonstrate ARAR compliance. Because the Surface Barrier alternative, including ISG, would adequately address identified ARARs, no known administrative barriers would exist to prohibit implementation.

Safety disciplines, including radiation safety, industrial hygiene, and construction safety, are readily available at the INEEL. Regulatory compliance support is available at the INEEL. Any changes to the storm water systems may require some environmental assessment. This issue is not anticipated to adversely affect the administrative implementability of this alternative.

Because of the potentially significant exposure to radiological contaminants, perhaps the most challenging issues with any remedial action taken at the SDA would be demonstrating readiness to conduct safe operations and obtaining administrative approval to commence operations. Activities of the Surface Barrier alternative would involve primarily standard construction work conducted on the surface of the SDA. However, the need to control future subsidence would generate some level of radiological and nuclear material hazard. The process of safety analysis, design, and operational readiness for systems and techniques to control subsidence would be complex. However, the safety analysis and design work already completed for ISG at the site, along with past technology performance tests, would likely reduce the requirements for any postROD safety analysis.

The Surface Barrier alternative would be administratively feasible for WAG 7. Long-term monitoring activities, cover-maintenance activities, and 5-year site reviews would require long-term coordination; however, these activities would not present significant administrative difficulties.

4.3.2.6.3 Availability of Services and Materials—Services and materials required to implement the Surface Barrier alternative include mechanical hauling and grading, constructing a grout batch plant, hauling grout materials, in situ nonreplacement jet grouting of the subsurface, hauling and placing materials to construct a multilayered cover, installing storm flow diversions, constructing fences and other access controls, and site restoration including grading and reseeding.

All earthwork under this alternative would involve using readily available standard construction equipment, trades, and materials. Soil and rock could be borrowed or quarried from regional sources. Services and infrastructure for construction activities are readily available in the local region, and services and materials for the jet grouting are available nationally from a number of commercial vendors.

Preliminary assessments indicate that suitable materials are available from borrow areas on and off the INEEL. However, this project would require extensive excavation within the designated areas. For example, approximately 3.5 million yd^3 of silt loam materials would be required to complete construction of the cover. Assuming this was retrieved from a single pit with an average extraction depth of 20 ft, it is projected that the pit surface would cover approximately 100 acres.

4.3.2.7 Cost (Balancing Criterion). The net present value of the Surface Barrier alternative is estimated at $616.1 million, which includes $609.4 million for capital and $6.7 million for operating and maintenance (O&M). The primary capital costs are associated with the surface barrier construction. The primary O&M costs are associated with the environmental monitoring conducted during the 100-year period. Table 4-7 provides a summary of both the total project costs and the net present-value estimates. The costs include an estimated average 33% contingency.

Table 4-7. Estimated costs for the Surface Barrier alternative with contingency.

Cost Element	Total Costs ($M)	Net Present Value ($M)
Capital costs		
In situ grouting and foundation grouting	246.5	—
Surface barrier	154.2	—
Volatile organic compound treatment using ISTD	104.3	—
Pad A retrieval and reconfiguration	163.0	—
Testing	13.0	—
Management, design, and reporting	78.9	—
Total capital costs	795.0	609.4
Operating and maintenance costs		
Monitoring and surveillance	31.5	—
Cover maintenance	9.0	—

Table 4-7. (continued).

Cost Element	Total Costs ($M)	Net Present Value ($M)
Fencing and signage	0.3	—
Management	4.9	—
Total operating and maintenance costs	45.7	6.7
Total cost for alternative	**841.6**	**616.1**

ISTD = in situ thermal desorption

4.4 Alternative 3—In Situ Grouting

4.4.1 Alternative Description

In Situ Grouting Alternative Remediation Strategy

Stabilizing buried waste through in situ grouting. Future exposure to the stabilized waste would be prevented through implementing administrative and physical land-use restrictions including placement of a low-permeability or biotic-barrier cover system.

Key Elements:
(1) In situ grouting of buried waste
(2) Retrieval and ex situ stabilization of Pad A waste
(3) Pretreatment of high organic areas using in situ thermal desorption
(4) Placement of low-permeability cover system
(5) Physical and administrative land-use restrictions
(6) Long-term monitoring and maintenance.

This alternative would rely on ISG as the primary technology to treat the COC-bearing waste streams within the SDA. The technology would be applied to RFP TRU waste in Pits 1 through 6 and 9 through 12, and Trenches 1 through 10. Other waste sites, including the SVRs and other locations at which elevated levels of C-14 and other COCs are found, also would be treated with ISG to immobilize COCs. Any remaining untreated disposal areas would be grouted in place, as necessary, to ensure a stable foundation for a protective, low-permeability cap that would cover the entire SDA.

The ISG technology would encapsulate waste and associated contaminants in a stable monolith designed and implemented to reduce contaminant migration from the site to acceptable levels. Grouted waste material would be further isolated from potential future human or ecological receptors through construction of a low-permeability biotic barrier cover system. Other supplemental technologies would include using ISTD as a pretreatment for high organic waste streams within the SDA to facilitate successful application of ISG. In addition, because of high nitrate content in Pad A waste, this alternative would include retrieval and ex situ treatment to ensure compliance with the RAOs.

Components of this alternative are described in following subsections. Grouting technology and applications are discussed in detail by Armstrong, Arrenholz, and Weidner (2002).

4.4.1.1 Primary Technology—In Situ Grouting. The term *in situ grouting* is used broadly to describe various techniques that apply stabilizing agents to the waste site. The process entails injecting a slurry-like mixture of cements, chemical polymers, or petroleum-based waxes into contaminated soil or waste landfill. Grouts are specially formulated to encapsulate contaminants, isolating them from the surrounding environment. As used in the environmental industry, the process is described as nondisplacement jet grouting whereby soil and waste debris are mixed subsurface, forming a large grout monolith (DOE-ID 1999; Loomis, Zdinak, and Bishop 1997). Grouting is accomplished without displacing contaminants or debris or ground heaving. Overall site volume remains constant, but the site density is increased substantially.

Grout is typically pumped into the waste zone under pressure using an injection lance. Injection lances are direct-pushed into the waste zone using rotary percussion action, which minimizes potential for surface contamination. The injection method produces interlocking columns of grout extending from the underburden soil up through the waste, terminating subsurface in the overburden. Interlocking columns cure into a solid monolith with no discernable edges between columns. Containers of waste are filled from the inside with grout. When injected under high pressure, the cutting action of the jets fractures low-strength objects and thoroughly mixes waste particles with the grout. Large objects remain in place as the grout flows under pressure into voids around the objects. All readily accessible voids are filled (Loomis, Zdinak, and Bishop 1997).

Based on results of past field trials at the INEEL, high-pressure injection grouting would be well-suited for ISG of the SDA. The low porosity of soil and presence of containerized waste requires injection of grout at relatively high pressures and at very dense spacing. That spacing would allow every waste drum to be physically pierced by the injection lance to ensure drum contents are treated (Loomis, Zdinak, and Bishop 1997). For the purpose of this PERA, it is assumed that rotary-point injection would be used for the pits and trenches where intimate mixing of waste and grout is desired.

Though numerous individual grout formulations are commercially available (many of them applicable to the SDA), several representative grouts are presented for purposes of this PERA evaluation. The primary grout type is ASTM Portland cement, which has the most performance data available and is readily available and relatively inexpensive. The secondary grout type represents more complex formulations that cure into very dense products analogous to hematite or other naturally occurring minerals. The commercially available grout (e.g., Gment-12) is a cementitious grout containing blast-furnace slag. Because of recent testing, commercial grout is a strong candidate for application at the SDA (Loomis et al. 2002). Other commercially available products (e.g., TECT, which was used in the past to stabilize low-level radioactive and mercury-contaminated soil at the SDA [Loomis et al. 1998]) also would be thoroughly evaluated during the remedial design phase. The actual selection of grouts would include parameters (e.g., COCs, remediation goals, costs, and compatibility with the injection equipment). The specific formulations would require careful evaluation and testing during the remedial design to optimize grouts for each different type of waste. This evaluation assumes that the grout (Gment-12) would be applied universally across the SDA.

The basic grout injection techniques and equipment have been repeatedly demonstrated, as discussed in Section 2. Using a direct-push injection lance and system of high-pressure pumps has been shown to be effective and implementable (Armstrong, Arrenholz, Weidner 2002). Though some safety analysis and testing has been performed, the question of how best to control potential surface contamination is still outstanding and would need to be resolved during the remedial design should this alternative be selected.

In situ grouting would be conducted under a radiological confinement building and that workers would be remotely located during grout injection. The structure would be a modular steel building erected in linear sections to allow the ISG system to progress down a long row inside the structure. The structure would be maintained under negative pressure and ventilated through a HEPA filter system. The structure would be continually disassembled and moved as the ISG operation progressed across the SDA. Because preliminary analyses indicated that the potential for airborne contamination is very low, it is not anticipated that the building would become highly contaminated. A robust system of radiation monitors inside the structure would be used to verify that contamination is maintained at acceptable levels. Because contaminated material could reach the surface of the overburden during implementation, the ground surface would be covered with approximately 2 ft of soil after operations cease, but before the building is moved, to ensure that no contamination would be left exposed on the ground surface. Worker-risk issues are discussed further in Section 4.4.2.6, as well as in the supporting report (Armstrong, Arrenholz, Weidner 2002).

Past ISG work typically used trucks or small tractors to move the grouting apparatus from hole to hole. However, for an area as large as the SDA, an alternative deployment system would be more practical. In the large pit areas where thousands of injections would be required on 2-ft centers, a crane system would be recommended for maneuvering the injection lance (Loomis 2001). Instead of being fastened to a truck bed or small tractor, the mast and hydraulic head would be mounted on the crane's transverse beam. The crane would be operated remotely to incrementally position the injection lance over each hole. Pumps would be located remotely and no personnel would be required near the injection area during operations. To improve implementability, a wheel-mounted crane would be used. Tire-mounted cranes are available with self-contained diesel drives that would facilitate moving the grouting system across the SDA. Using tire-mounted cranes also eliminates the need for supporting rails. Tire-mounted gantry cranes are commercially available with suitable load capacity and spans up to 60 ft.

Some uncertainty is associated with using a wheel-mounted crane because the apparatus has not been used previously at the SDA. Some engineering and testing would be required during remedial design to ensure a suitable system is obtained. However, ISG would be implementable regardless of the platform used to mount the injection equipment. For purposes of the evaluation, the crane system is the primary deployment platform.

A number of steps would be required for implementing an in situ technology (e.g., ISG) within the SDA. Figure 4-5 provides a conceptual process diagram that overviews implementation of this technology. The key tasks identified in the figure are discussed below.

4.4.1.1.1 Safety Analysis and Remedial Design—The initial step of all remedial alternatives would entail a thorough engineering design and analysis of hazards. This evaluation assumes, based on the *Operable Unit 7-13/14 Preliminary Safety Analysis Report for In Situ Grouting at the Subsurface Disposal Area* (Peatross 2001), that the ISG operation would be classified as a low-hazard radiological operation. To ensure safety of workers, the remedial design would require that engineering and administrative controls be developed, tested, and demonstrated to be effective.

Engineering aspects of remedial design would draw heavily on existing equipment and techniques. However, using a wheel-mounted crane would require additional design engineering to mount the drill mast and hydraulic head to the crane. The crane and drill injection system would be fabricated to specification by commercial vendors. Lights and camera systems also would be fabricated, installed, and tested. All intrusive alternatives would be field-tested before operations began to determine that the system, as delivered, meets all requirements.

While numerous grouts are commercially available, site- and equipment-specific formulation testing would be required. Application at the SDA would be complicated by the presence of a wide variety of waste types. Several areas in the SDA may have extremely high concentrations of problematic waste types that would require developing and testing specialized grouts.

4.4.1.1.2 Infrastructure—The SDA is contained within the RWMC, a 200-acre facility where radiological and hazardous materials are routinely handled, stored, characterized, and shipped. Radiation engineering, maintenance, utilities, and other support services are available at the RWMC. Power, water, roads, transportation, and cafeterias also are available nearby.

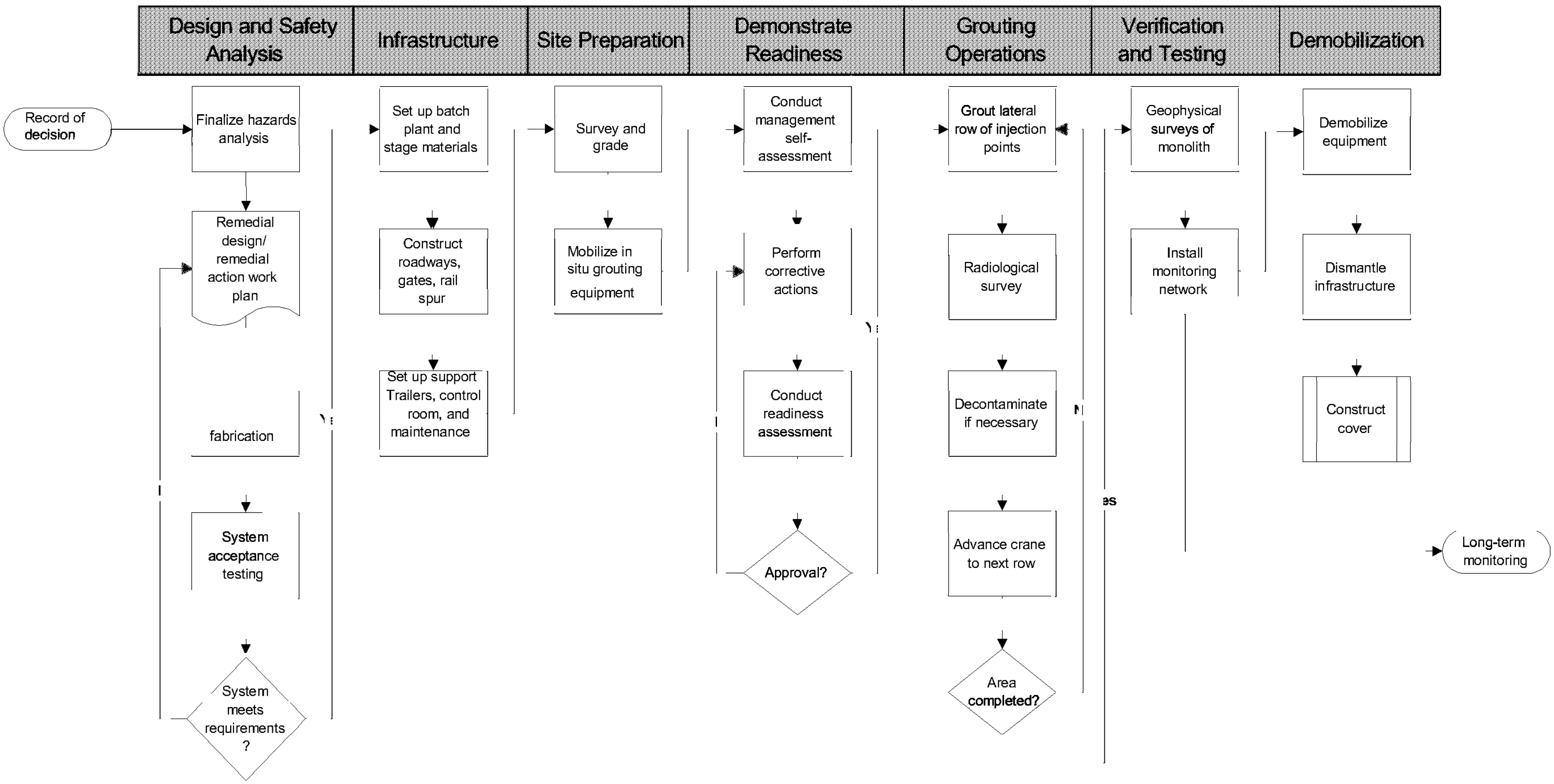

Figure 4-5. Conceptual process flow for the In Situ Grouting alternative.

However, to support ISG operations, some facility modifications would be required. A grout batch plant would be constructed near the SDA. Previously, cement batch plants have been located adjacent to the SDA. Several locations immediately adjacent to the SDA are suitable for this purpose and have power and water available nearby. Materials to formulate the grout would be shipped from vendors by rail car. An active rail spur runs to the RWMC. Trailers similar to those currently used at the RWMC would be installed in the SDA to support operational controls, radiation controls, and personnel facilities. Pump housing also would be installed to contain the high-pressure pumps and feed systems. The pump house would be designed to interface with the grout delivery trucks. Temporary electrical lines would be run aboveground to provide power to the ISG operational areas.

4.4.1.1.3 Site Preparation—Minimal site preparation would be required for ISG. The SDA is relatively level and well-graded. However, areas with drainage ditches, roads, and miscellaneous equipment would require some grading and fill to ensure level terrain to operate the crane system.

Areas to be grouted would be surveyed and engineering drawings made. A suite of geophysical surveys would be conducted to determine pretreatment conditions of the waste zones. High-resolution electromagnetic and sonic techniques have been used at the SDA to discern waste edges and other subsurface features. In addition, geophysical probes using active and passive neutron and gamma surveys would be deployed to help discern activity levels of the waste to be grouted. Recent active logging of Pit 9 (OU 7-10) has shown the relative difference in moisture content between soil and waste can be useful in mapping the geometry of the waste zone. Survey data would be correlated with disposal records to validate the dimensions of the areas to be grouted. The final step of site preparation would be to mobilize the grouting equipment to the ISG operational area.

4.4.1.1.4 Demonstrate Readiness—Though the ISG operation likely would be classified as a low-hazard, nonnuclear operation, worker safety is paramount. A rigorous process of safety reviews, identification of deficiencies, and corrective actions would be performed before starting operations.

4.4.1.1.5 Grouting Operations—Grouting operations would commence with positioning the injection crane system over the first grout area. It is envisioned that the injection lance would be moved in short increments laterally across the span of the crane and that the crane would be incrementally advanced forward across long strips of ground. Actual positioning, spacing, and sequencing of drilling would be optimized during remedial design. This evaluation assumes that grout would be injected on a triangular pitch grid at approximately 20-in. centers to ensure every buried waste container would be grouted on the inside.

The grout would be mixed at the batch plant adjacent to the SDA and delivered by truck to the ISG operational area. The grout truck would be received at the pump house and the grout fed into the high-pressure positive displacement pumps. A system of high-pressure lines would deliver grout to the injection lance.

The injection lance would be driven with rotary percussion action into the soil and waste to a depth of 20 ft or until refusal. Refusal would be defined in remedial design, based on rate of advancement to avoid exceeding operating limits of the equipment. Refusal likely would occur at varying depths because elevation of basalt bedrock varies widely. In addition, large objects (e.g., steel debris) would cause refusal. If the operator concludes that refusal was caused by an impenetrable object, the injection pattern would be modified to inject around the object to encase its perimeter. Once the maximum depth has been reached, the drill stem rotation and high-pressure displacement pump would be started. Grout would be pumped down the center of the injection lance and out two jet nozzles at the tip. The injection lance would be rotated and retraced at a predetermined rate proven to ensure good grout placement. Most of the grout on the drill stem would be scrubbed off when the stem is retracted through the overburden. Grouting would be stopped at the waste and overburden interface. The objective would be to avoid unnecessarily grouting the overburden or forcing grout to the surface.

After each hole is completed, the injection lance would be fully retracted and the lance assembly surveyed remotely for radiological contamination. High-volume air monitors mounted on the crane near the injection lance also would be used to detect any airborne contamination. If contamination were detected, the equipment would be decontaminated. The injection lance would be moved laterally one increment and the injection process would be repeated. After all points under the span of the crane are grouted, the crane would be walked forward an increment and the process repeated.

After a section has been grouted, operations would be suspended temporarily to allow for placing a soil cover over the grouted areas. A 3-ft thick cover of soil over all grout returns, spills, and drips would help maintain a clean environment inside the containment structure and would prevent possible erosion and resuspension of contaminants after the building has been removed.

In the SVRs, a modified approach would be used. Because the SVRs comprise a series of individual vaults (i.e., unlined holes augured into the soil), grout would be injected at each vault position rather than on a rigid grid such as that defined for pits and trenches. Approximately 650 individual soil vaults are arranged in long lines and spread across a number of areas within the SDA. Soil vaults are small, with a diameter of approximately 16 in.; and large, with a diameter of approximately 57 in. The injection lance would be inserted on the perimeter of each vault making two injections for each small vault and four injections for each large vault. The purpose of grouting would be to encapsulate waste by filling void spaces in the soil vault surrounding the waste. Soil above and below the waste also would be grouted. Because grouting soil vaults has not been performed before, some field testing would be recommended to ensure safe operation in SVR areas.

4.4.1.1.6 Verification and Testing—Following injection of grout, posttreatment geophysical surveys would be conducted to verify the extent of the grout monolith. High contrast in moisture content and density would be used as indicators of the vertical and horizontal extent of the monolith. Operational data, including pressures and volumes of grout injected over each area, would be evaluated to verify the thoroughness of each grouting campaign. Additionally, a network of monitoring probes would be installed throughout the monolith before curing to collect moisture and vapor samples and to monitor temperature, reduction, and pH conditions.

4.4.1.1.7 Demobilization—After each grouting campaign, equipment and trailers would be demobilized and decontaminated as necessary. As each portion of the SDA was grouted, cap construction would commence, which would include foundation grouting in the untreated areas.

4.4.1.2 Supplemental Technologies. To provide compliance with the RAOs, the ISG alternative would require implementation of a number of supplemental technologies within the SDA to address contaminant-specific concerns and provide for the long-term stability of the cover system.

4.4.1.2.1 Organic Pretreatment—The areas that contain oil waste in very high concentrations (Series 743 sludge) may not be effectively grouted with cementitious grouts. Series 743 organic sludge originating from the RFP contains high oil content (averaging 37 gal/drum) and a greasy-like consistency (Clements 1982). In previous tests with simulated waste, researchers have had difficulty in grouting oil-based waste (Loomis and Thompson 1995). More recent testing has demonstrated success in grouting waste streams with 10 to 12% oil using a wide range of grout types.

For the ISG alternative, the ISTD technology would be applied in areas within the SDA containing high concentration of Series 743 organic sludge. Because of previous analysis (Miller and Varvel 2001) of the distribution of this waste stream as depicted in Figure 3-8, it is estimated that a total area less than 1 acre in size would have these high concentrations and require pretreatment. These areas are located primarily in Pit 4, with smaller distributions in Pits 6, 9, and 10.

A detailed discussion about implementing ISTD within the SDA is in Section 4.5.1.2. Determination of specific pretreatment requirements would be further evaluated during the design phase.

4.4.1.2.2 Pad A Treatment**—**Drums of nitrate salt (Series 745 sludge) stacked on Pad A may preclude using in situ treatment options. A number of grouts are available (e.g., silica- or hydrocarbon-based grouts), which conceptually would provide effective treatment for nitrate salt. However, the available performance data about application of ISG to pure salt waste are limited. Because waste loading could be extremely high (approaching 100 wt%) in areas of pure salt waste, ISG would not be as effective as an ex situ stabilization process. Therefore, this evaluation assumes that the waste from Pad A would be retrieved and stabilized in an ex situ treatment system. Waste would be retrieved from Pad A and segregated based on treatment process. This evaluation assumes that all of the Pad A waste would need to be processed. The retrieval process for Pad A is discussed in Section 4.6.1.3.

Waste streams present in Pad A would be stabilized with an ex situ treatment. Presently, specific information about the waste streams disposed at Pad A is unavailable. However, in general it is known that the waste was composed primarily of nitrate salt, depleted uranium, and sewage sludge (Becker et al. 1998). Though the Pad A site could be grouted in situ, effectiveness is highly uncertain without a more detailed understanding of types and concentrations of the waste.

The specific stabilization process would need to be determined after a thorough evaluation of waste types, but it is envisioned that the granular nitrate and oxidized uranium chips would be mixed with stabilizing agents in a pug mill. The *Mixed Waste Salt Encapsulation Using Polysiloxane—Final Report* (Loomis, Miller, and Prewett 1997) states that DOE-Complex salt waste (e.g., Pad A nitrate salt) was suitable for grout stabilization. The resultant grouted waste form passed the toxicity characteristic leaching procedure and U.S. Department of Transportation oxidizer testing. Based on these tests, it is assumed that nitrate salt would be conducive to ex situ treatment. However, small amounts of waste in Pad A exceed 100 nCi/g TRU, and other waste may be determined to carry additional RCRA-listed waste codes (e.g., F001). This waste would be evaluated on a case-by-case basis and might necessitate additional disposal requirements. Waste that exceeds 100 nCi/g TRU likely would be disposed of at WIPP. NonTRU waste requiring a Subtitle C constructed landfill for disposal (i.e., listed waste) may be sent to the ICDF or other commercial TSD facility. Debris waste, if requiring treatment, likely would be macroencapsulated in polyethylene. Both stabilization and macroencapsulation processes are used at commercial mixed waste disposal facilities. Some study may be required to define operational parameters (e.g., proper melt indices) to ensure that cracking or spalling of the treated waste form would not occur. Following stabilization and macroencapsulation, the Pad A waste would be placed back into a pit in the SDA and would be covered by the modified RCRA Subtitle C cap.

A majority of the waste in Pad A includes nitrate salt, which currently are assumed to carry characteristic EPA waste codes (i.e., D001). Detailed analyses of all Pad A waste types have not been performed at this stage; therefore, other code applications are unknown. Further characterization would occur upon waste retrieval. If the waste types were characteristic only (as suspected with the nitrate salt), then the characteristic codes might be removed through treatment. Underlying hazardous constituents (UHCs) and corresponding universal treatment standards (40 CFR 268.48) also would be evaluated before redisposal. For this evaluation, it is assumed that a Subtitle C landfill would not be required.

4.4.1.2.3 Surface Barrier**—**Following completion of ISG, a modified RCRA Subtitle C cap would be constructed to limit infiltration of water, further reduce contaminant mobility, and inhibit future access to the stabilized waste. The modified RCRA Subtitle C cap would be composed of eight layers of material with a combined minimum thickness of 1.7 m (5.6 ft). The modified RCRA Subtitle Cap is designed to provide containment and hydrologic protection for a performance period of 500 years. Before construction of the cap, untreated waste areas would be grouted to stabilize the foundation and minimize future subsidence-related maintenance requirements.

Construction of the barrier would involve placing a site-grading fill within the SDA to eliminate any depressions and facilitate positive perimeter drainage. Site-grading fill would be followed by layers of sand mixed with gravel, and cobbles. The perimeter of the barrier would be sloped at 3:1 and armored with riprap to prevent its erosion. A perimeter berm system also would be constructed to maintain any floodwaters at least 100 ft from the toe of the cover to minimize moisture movement into the stabilized waste zones.

The alternative assumes that the OCVZ system would continue to operate. Concurrently with construction, wells supporting the OCVZ system would either be extended or relocated, as necessary. The cover design also includes a gas collection layer to passively vent VOC releases from buried waste.

4.4.1.2.4 Monitoring and Maintenance—This alternative involves performing routine maintenance to address potential issues (e.g., burrowing animals and erosion). Groundwater, vadose-zone, and air monitoring activities conducted as part of this alternative would facilitate identification of contaminant migration or other changes in site conditions that may warrant future remedial actions. Table 4-8 identifies the alternative's monitoring activities, which would be conducted in concert with the scheduled operations and maintenance activities of the INEEL-wide program.

Table 4-8. Projected monitoring requirements for the In Situ Grouting alternative.

Media	Sampling Strategy
Groundwater	Sample 16 locations quarterly for 2 years; semiannually for the following 3 years; annually for the remaining 95 years.
Vadose zone	Sample lysimeters (37) and vapor port (20) quarterly for 5 years and annually for the remaining 95 years.
Air	Sample four existing air monitors annually for 100 years.
Surface water	Sample two points every 5 years for 100 years.
Biological	Conduct animal intrusion inspection during vegetation monitoring.
Vegetation	Conduct annual inspections for 5 years; every fifth year for the next 20 years.

4.4.1.3 Estimated Schedule. The entire ISG alternative is estimated to be complete within 12 years from ROD signature. Figure 4-6 graphically illustrates the task schedule for the ISG alternative.

As shown, the remedial design and procurement phase, including grout-formulation testing, procurement and fabrication, and acceptance testing of the equipment is estimated to require 3 years. Upgrading the necessary infrastructure would be done concurrently during this time. Operations to treat the pit areas, SVRs, and trenches containing TRU and C-14 sources would be completed in approximately 5 years if operations were suspended a quarter of the year (during winter months) and three grout rigs were operated simultaneously. Pad A waste would be retrieved and treated concurrently with the grouting operation. Cap construction also would be concurrent with the grouting operation, with completion approximately 1 year after treatment operations are finished.

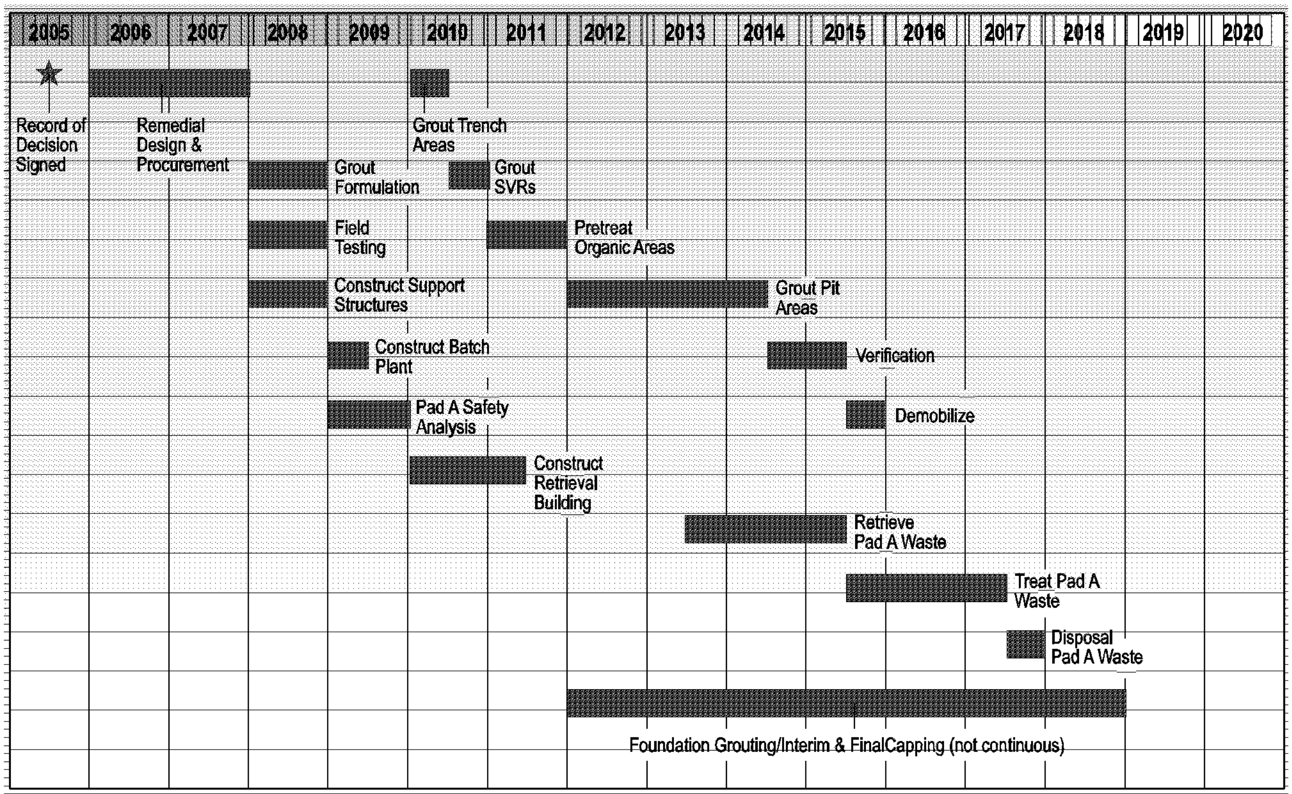

Figure 4-6. Schedule for the In Situ Grouting alternative.

4.4.2 Screening Assessment

In the following sections, an assessment is provided of the ISG alternative's ability to satisfy the two threshold criteria and the five balancing criteria described in Section 4.1.

4.4.2.1 Overall Protection of Human Health and the Environment (Threshold Criterion). The ISG alternative would protect human health and the environment. It is projected that the alternative would be implemented by 2019 and would achieve all of the RAOs. Because contaminants would remain at the site, monitoring would be a required element of the alternative.

4.4.2.2 Compliance with Applicable or Relevant and Appropriate Requirements (Threshold Criterion). The ISG alternative is designed to stabilize and contain buried waste through injection of a stabilizing grout and installation of a surface barrier. In addition, waste in Pad A would be retrieved and stabilized in an ex situ treatment system. The key ARARs for this alternative, therefore, relate to containing buried waste over time and identifying and managing RCRA hazardous waste. Under CERCLA, ARAR compliance is addressed by considering chemical-, location-, and action-specific ARARs (and TBCs) independently. Appendix A presents a comprehensive summary of potential ARARs that have been identified for the WAG 7 feasibility study. The evaluation summary of the key ARARs for the ISG alternative is presented in Table 4-9. Each requirement is identified by its type (i.e., chemical-, location-, or action-specific), its relevance (i.e., applicable, relevant and appropriate, or TBC), and the regulatory source citation. The table also presents a conclusion as to whether the proposed alternative would meet a corresponding requirement. Detailed discussions of significant requirements are presented below.